THE FUNCTIONAL CHARACTERISTICS OF THE MYELINATED FIBERS OF THE SPLANCHNIC NERVES

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The splanchnic nerves, which belong among the basic paths of the afferent and efferent innervation of the abdominal organs, have long attracted the attention of investigators. Not a few papers have been devoted to their macroscopic structure. During the last 50 years, many investigations have been carried out which were devoted to the microscopical and functional characteristics of these nerves. An extensive literature has accumulated on these problems. However, many problems still remain unclear, unsolved regarding the morphological and physiological significance of these important paths of innervation of the abdominal organs.

Myelinated and amyelinated fibers occur in the splanchnic nerves. It is considered that the amyelinated fibers are postganglionic sympathetic ones, although the possibility is not excluded that there are afferent fibers among them since a large number of amyelinated fibers occur in the dorsal horns of the spinal cord.

The myelinated fibers of the splanchnic nerves can be divided into two basic groups: the large (diameter 8-15 μ) and small (diameter 3-5 μ) ones. Fibers with a diameter of 5-8 μ are rare; they need not be put in a separate group.

There is no consensus among investigators regarding the functional assignment of these fibers, which differ in their structure. W. Gaskell [10] assigned the fine myelinated fibers to the preganglionic sympathetic, the thick ones to the efferent fibers. F. Edgeworth [9], studying serial sections of the peripheral sympathetic trunk and connecting branches, showed that the large myelinated fibers in the peripheral branches of the sympathetic nervous system belong to the dorsal horns. He confirmed his data by experiments on animals with stimulation of the dorsal horns and stripping of the spinal ganglions, after which he discovered degeneration of the thick myelinated fibers in the peripheral sympathetic trunk. V. M. Godinov [1], studying the origins of the afferent innervation of the portal vein, reached the conclusion that, in addition to the thick fibers, part of the small myelinated fibers of the splanchnic nerves are afferent. He called them "vascular receptor fibers."

Thus, some investigators assign the fine myelinated fibers in the peripheral sympathetic trunk and its visceral branches to the preganglionic sympathetic ones, others consider that there are afferent fibers among them along with sympathetic ones. Both groups of authors do not have the facts which would directly prove the correctness of their statements.

The physiological characteristics of the splanchnic nerve fibers are considerably more varied than the morphological ones. The efferent impulses which cause the contraction and relaxation of the intestines [7], vasomotor [11] and afferent impulses travel along the splanchnic nerves. O. Foerster, H. Altenburger and T. Kroll [9] consider that the majority of the afferent impulses from the viscera travel along the splanchnic and cardiac nerves. The splanchnic nerve, according to them, is basically the sensory nerve of the abdominal organs.

V. E. Delov, P. A. Kiselev, M. A. Adamovich and O. M. Zamyatina [3] investigated the afferent impulses of the splanchnic nerves. In experiments with transsection of the splanchnic nerves of a cat, these investigators registered, on a cathode oscillograph, the afferent potentials from their peripheral ends. They succeeded in establishing that, in fasting animals, both group as well as intergroup potentials were absent in the splanchnic nerve; on the contrary, the fuller the stomach and intestines were, the stronger were both types of potentials.

It has been shown experimentally that the afferent impulses from the abdominal organs, most of which travel through the splanchnic nerves, have an effect on the functioning of all levels of the central nervous system, up to the cerebral cortex [4, 5, 6].

I. T. Kurtsin [4] established that mechanical stimulation of the gastric mucosa caused a stream of nerve impulses which were transferred by afferent pathways to the higher sections of the central nervous system and sharply changed the course of the cortical processes. At the same time, inhibition of conditioned reflex activity is observed. B. V. Pavlov [5] showed on dogs that unilateral transsection of the greater and lesser splanchnic nerves leads to a decrease in conditioned and unconditioned reflexes. He observed a strengthening of the stimulant and weakening of the inhibitory processes.

The problem of the present investigation was to show the reaction of the respiration and blood pressure to stimulation of the de-efferented and de-afferented greater splanchnic nerves and to find out which myelinated fibers of the splanchnic nerves are afferent and which ones efferent.

EXPERIMENTAL METHODS

The investigation was carried out on 10 cats. Four of them served as controls, while 3 series of operations were carried out on the remainder – 2 animals in each series.

As is known [2], the greater splanchinic nerve receives preganglionic sympathetic fibers from the T_{5-12} segments of the spinal cord, and its afferent fibers from the 5–11 thoracic paravertebral ganglions. Based on this, we disconnected the preganglionic sympathetic fibers of the left greater splanchnic nerves of 2 cats by cutting the 5–12 ventral horns in the left thoracic section. In 2 cats, the 5–11 thoracic paravertebral ganglions on the left side were removed (deafferentation of the greater splanchnic nerves). In 2 more animals, the 5–11 dorsal roots were cut in the thoracic section on the left side and in the same way, the connection between the afferent fibers of the greater splanchnic nerves and the spinal cord was destroyed. The operations were carried out under hexanal narcosis. After the operations, the animals lived 3–4 months. Then, under hexanal narcosis, their splanchnic nerves were dissected out, placed on electrodes and stimulated by a faradic current. The respiration (the T-piece was tied into the trachea) and the blood pressure (the cannula was tied into the common carotid artery) were recorded on the sooty ribbon of a kymograph with Marey's capsule.

Then the animals were killed, pieces of the splanchnic nerves were prepared by Pal-Weigert's method.

EXPERIMENTAL RESULTS

Clearly evident changes in the number and quality of myelinated fibers were found in cross sections of the greater splanchnic nerves on the left side of the experimental animals. The greater splanchnic nerve of the control cats had a unifascicled structure in the majority of cases. Among its myelinated fibers, the thin ones with a diameter of 5 μ predominated, their average number was 2700 (Fig. 1a). Along with them, many large myelinated fibers were found in the greater splanchnic nerve, an average of 230 (130-400). The total number of myelinated fibers was from 2300 to 4100, averaging 2950.

An absence of the large and medium myelinated fibers was noted in the greater splanchnic nerves on the left side of the deafferented cats, the number of small myelinated fibers decreased to 1400 (Fig. 1b). If extirpation of the spinal ganglions is assumed to lead to the destruction of only the sensory fibers, it can be concluded that all the large and medium myelinated fibers and approximately half of the small myelinated fibers are afferent fibers in the greater splanchnic nerves.

Among the animals whose ventral horns were cut, the total number of myelinated fibers decreased to 1350 in the greater splanchnic nerves. The decrease in their number occurred at the expense of the small myelinated fibers. If their number among the control animals was 2700, then in this case it was only 1200 (Fig. 1c). Thus, only the small myelinated fibers should be related to the preganglionic sympathetic fibers of the splanchnic

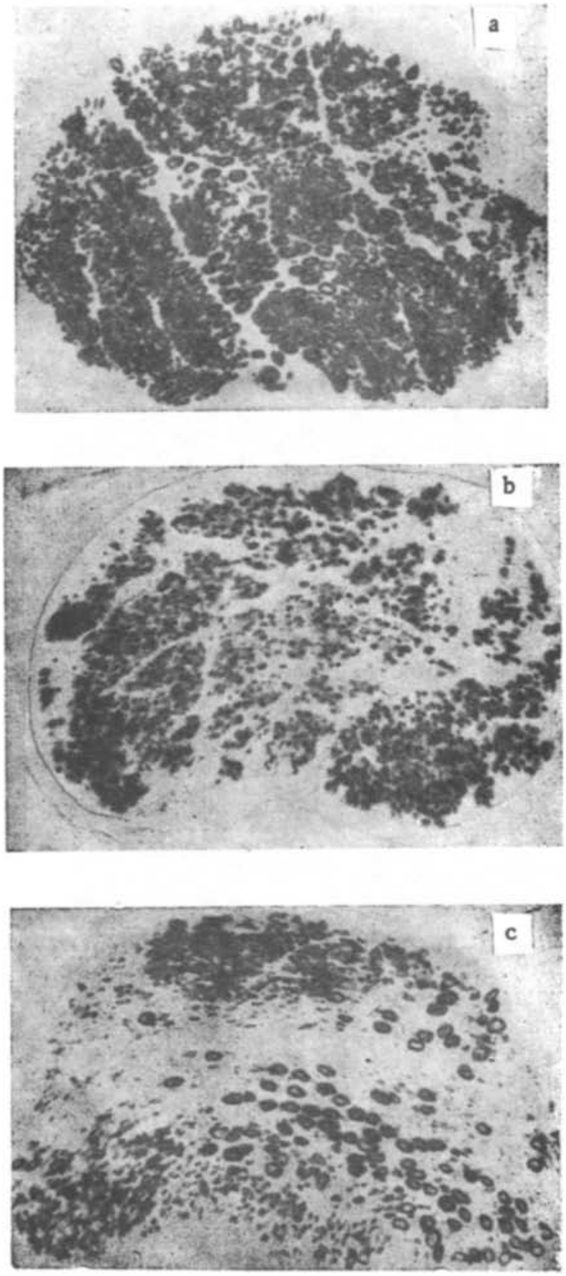

Fig. 1. Cross sections of the greater splanchnic nerve. a) control cat; b) the nerve deprived of its afferent paths (large myelinated fibers are absent); c) the nerve, deprived of its preganglionic sympathetic fibers (Pal-Weigert's stain).

nerves; they consist of slightly more than half of all the fibers with a diamter up to 5μ. The number and nature of the myelinated fibers in the greater splanchnic nerves of cats whose dorsal horns were cut did not differ in any way from the architectonics of the splanchnic nerves of the control animals. This is explained by the fact that cutting the central process of a pseudounipolar cell of the spinal ganglion does not lead to the destruction of its peripheral process, although, from the point of view of function, here also there can be discussion of the deafferentation of the splanchnic nerve, since there is no connection between its sensory fibers and the spinal cord.

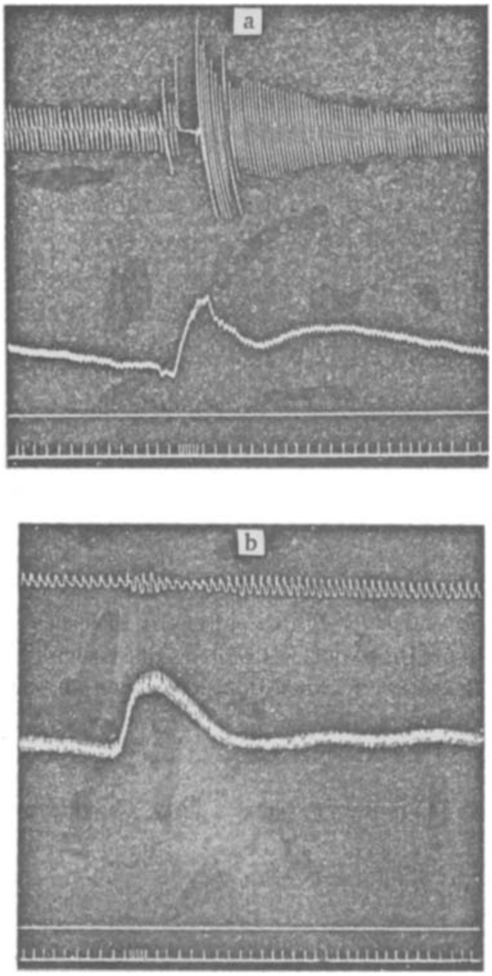

Fig. 2. Kymogram of the respiration and blood pressure when the greater splanchnic nerve is stimulated. a) control cat; b) the same with a deafferented nerve.

The above morphological differences among the greater splanchnic nerves of the experimental animals found their confirmation in their different functional characteristics: a different reaction of the blood pressure and respiration was found for each group of experimental and control animals caused by the splanchnic nerves. When the splanchnic nerves of the control animals were stimulated with a faradic current (Fig. 2a), a rise in the blood pressure, a deepening and increased frequency of the respiration was noted. Among the experimental animals with deafferented greater splanchnic nerves a rise in the blood pressure was noted and the respiratory reaction was absent (Fig. 2b). A similar picture could be observed also when the greater splanchnic nerves were stimulated on the left side of the cats, whose dorsal horns of the spinal cord were cut, – only their blood pressure reacted also.

The record of the respiration and blood pressure of the cats whose greater splanchnic nerves were deprived of the preganglionic sympathetic fibers had a different nature. As is evident in Fig. 3a, in this case a deepening and increased frequency of the respiration and a small rise in the blood pressure, in comparison with the blood

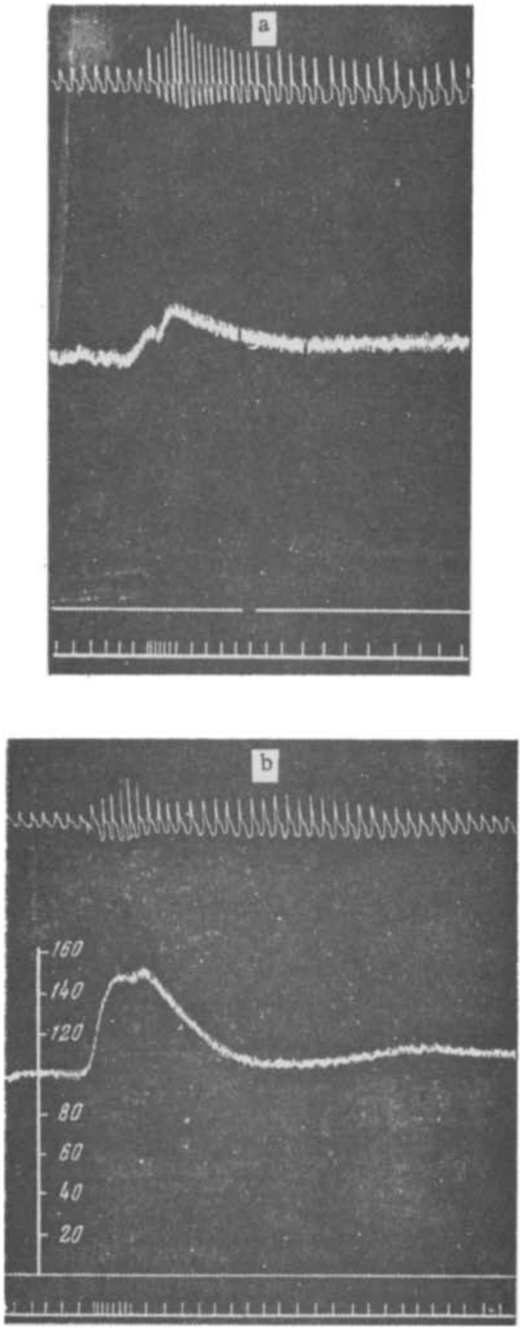

Fig. 3. Kymogram of respiration and blood pressure. a) with a deafferented greater splanchnic nerve; b) the same nerve on the right side of the same cat.

pressure when the right greater splanchnic nerve of the same cat was stimulated, occurred (Fig. 3b).

Experiments with stimulation of the splanchnic nerves showed that they consisted of efferent fibers only in one case (in those cases when the respiratory reaction was not observed), in the other case – of afferent ones with postganglionic sympathetic fibers; the presence of the latter caused the small rise in blood pressure (see Fig. 3a).

Thus, experiments with deafferentation and deefferentation proved that the greater splanchnic nerves are mixed; that all the large, medium and about half of the small myelinated fibers in them are sensory; the rest of the small myelinated fibers are preganglionic sympathetic ones. One can suppose that in the rest of the peripheral ramifications of the sympathetic nervous system also, the myelinated fibers are distributed by function in a similar manner.

SUMMARY

It is experimentally proved that all the large and middle medullated fibers, as well as about a half of the find medullated fibers belong to the afferent fibers of nervi splanchnici majores. To the efferent fibers of nervi splanchnici majores belong about a half of the fine medullated fibers contained in these nerves.

Stimulation of nervi splanchnici majores, devoid of the preganglionic fibers, with the faradic current brings about a deepening of the respiration and an increase of its rate, as well as a small elevation of the blood pressure owing to the presence of the postganglionic sympathetic fibers. Stimulation of the deafferented nervi splanchnici majores brings about an elevation of the blood pressure and does not affect respiration.

LITERATURE CITED

[1] V. M. Godinov, Byull. Eksptl. Biol. i Med., 1949, vol. 28, issue 2, No. 8. 141-143.

[2] A. S. Gusev, On the Structure of the Splanchnic Nerves, "Experimental Clinical Investigation. Dissertation,* Leningrad, 1954.

[3] V. E. Delov, P. A., Kiselev, N. A. Adamovich and O. N. Zamyanina in the book: Problems in the Physiology and Morphology of the Central Nervous System,* Moscow, 1953, pp. 31-37.

[4] I. T. Kurtsin, Fiziol. Zhur. SSSR, 1938, vol. 25, issue 6, pp. 885-905.

[5] B. V. Pavlov in the book: Abstracts of Reports at the Eleventh Conference on Physiological Problems, dedicated to the tenth anniversary of the death of I. P. Pavlov, Leningrad, 1946, pp. 49-50.

[6] V. N. Chernigovsky, The Afferent Systems of the Viscera,* Kirov, 1943.

[7] Bunch, J. Physiol., 1897-1898, vol. 22, p. 357.

[8] W. H. Gaskell, J. Physiol., 1886, vol. 7, p. 451.

[9] F. H. Edgeworth, J. Physiol., 1892, vol. 13, p. 260.

[10] O. Foerster, H. Altenburger, T. W. Kroll, Ztschr. f. ges. Neurol. u. Psych., 1929, Bd. 121, S. 139-185.

* In Russian.